UNIVERSITY OF CALIFORNIA · COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY 4, CALIFORNIA

THE PREVENTION OF MECHANICAL INJURY DURING TRANSIT OF NEW-CROP POTATOES[1]

W. R. BARGER,[2] E. V. SHEAR,[3] AND L. L. MORRIS[4]

The prevalence of injuries in new-crop White Rose potatoes from California has caused comment and concern in the eastern markets. These injuries not only impair the quality of the potatoes affected, but also cause spotting of the bags and lowering of the sales value of the whole consignment. The greatest injury occurs in the bags resting on the floor racks, but a lesser amount is found throughout. The potatoes in the bottom layer represent one sixth to one fifth of the load, and any improvement in their condition at arrival would have a definite effect on the total value.

During the 1943 and 1944 seasons, transit tests were originated in Kern County, California, in an attempt to evaluate the use of padding material on the floor racks of potato cars. In 1944, the amount of damage evident in unprotected bags was recorded upon their arrival at New York City. Observations also were made concerning the amount of injury apparent at loading time.

Under present marketing conditions floor pads apparently more than pay for themselves by reducing the amount of crushing and bruising of potatoes in transit. Many small bruises were found before shipping. The extent to which these affect the condition on arrival was not determined; but, since bruises occur, frequent inspection of packing-house equipment and insistence on careful handling by all operators might aid in preventing some of the damage that the potatoes show upon arrival. There is evidence that the "3 × 5" load, commonly used in California, does not carry so well as the pyramid-type load.

The potatoes used in these tests were U.S. No. 1 White Rose, fairly mature. For most of the tests, the washed potatoes were packaged in medium-weight burlap bags, holding 100 pounds each. A few shipments contained bags made of cotton sheeting. The cars were initially iced to capacity at Bakersfield after loading and were usually re-iced twice during transit (rule 247) to Atlantic Coast markets.

Loading Methods

Transit injury was studied in two types of loads, each containing 360 bags. In the 3 × 5 load, there were 11 stacks in each end of the car, 3 rows wide and 5 layers high, with all bags laid crosswise of the car (fig. 1). The doorway provided space for 30 bags, set in 2 crosswise rows. During loading, the potatoes were moved into the cars in piles of 5 bags on a hand truck. Each pile was placed in the car (without rehandling) by tipping or bumping it forward from the truck. The bottom bag was set on edge on the truck so that the pile could be tipped forward more easily during the loading operation; it remained in this position in the car. These bags on edge tended to roll or rock in transit which action could result in considerable abrasion of the potatoes next to the floor rack.

Fig. 1.--Arrangement of a 36,000-pound 3 × 5 load. There are 11 stacks in each end of the car, plus 30 bags in the doorway. Note that the bottom bags rest on their edges and are therefore subject to rocking in transit.

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[2] Associate Physiologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S. Department of Agriculture, Fresno, California.

[3] Associate Pathologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S. Department of Agriculture, New York, New York.

[4] Assistant Professor of Truck Crops and Assistant Olericulturist in the Experiment Station.

The pyramid load consisted of 5 double stacks of 30 or 31 bags each, arranged in both ends of the car. (A stub stack of 5 bags may be placed upright at each bunker making the load slope away from the doorway.) The 50 to 60 bags left over were put in two rows in the doorway.

Fig. 2.--Arrangement of a 36,000-pound pyramid load. There are 5 double stacks in each end of the car, plus 50 bags in the doorway. Note that the bottom bags rest flat.

The arrangement of the bags within a double stack is shown in figure 2. The bags for the doorway rows were laid crosswise of the car. Since each bag is handled separately, this load requires more labor than the 3×5 load; but the bags can be set firmly in place to minimize rocking in transit.

Description of Pads

In most of the tests, the floor pads were of matted excelsior enclosed in paper sleeves. They were about 1/2 inch thick, 12 inches wide, and 30 inches long, large enough to accommodate one bag laid flat. When laid in the car, they were spaced to permit circulation of air up through the floor rack.

Pads filled with pulped paper proved just as effective as excelsior pads. They were about 3/8 inch thick, 12 inches wide, and 96 inches long. These long pads were laid lengthwise of the floor, singly or in double-width strips, whichever method was needed to protect the floor face of the bags. Space was left between each double row of pads to permit air circulation up between the rows of bags.

Inspection of Potatoes

When the cars were unloaded, the potatoes were examined for injury and decay. The entire contents of several bags were scored. Cutting the bag so that the tubers were examined in about the same position that they occupied during transit gave an accurate picture of the occurrence of floor bruising. Deep injury included crushing, severe bruising and cracking (fig. 3), and other forms of deep mechanical injury. Nearly half the potatoes arriving with deep injury were unsalable. Shallow injury included bag marks or imprints of the bag material, slight bruises, and browned or discolored spots resulting from pressure or from rubbing against other potatoes in transit (fig. 4). Potatoes with shallow injuries were salable but, obviously, had lost some of their market quality. The browned spots here reported do not include the defect known as surface browning or wind injury. Browned spots caused by bruising occur on all parts of the tuber; they show evidence of pressure or rubbing, whereas surface browning after wind injury is found only on previously skinned areas. The decay encountered was mostly soft rot. Occasionally it was in an incipient stage, causing only slimy pits in the skin; but usually it was advanced, spreading slime and ooze to adjacent tubers.

Injury and decay were expressed as per cent of the number of potatoes per bag; the percentages given in the tables are averages for the bags representing a given treatment. Statistical significance between averages was determined by the usual "t-test."

Survey of Loads Not Protected by Floor Pads

Inspection, at the market, of bags not protected by floor pads showed (1) that most injury occurred in the bottom-layer bags; (2) that a fairly large number of potatoes were severely injured in transit; (3) that potatoes probably carry better in pyramid loads than in 3×5 loads (table 1). The potatoes in this survey were obtained from 15 cars at the time of unloading. Although the maturity of the various lots is not shown in the table, at arrival the browned spots and possibly some deeper injuries and decay were less in the more mature tubers--a fact indicating the importance of maturity for sound delivery.

With both methods of loading, the amount of deep injury was significantly greater in the bottom layer than in the rest of the load. Deep injury averaged 7.9 per cent in the bottom layers of the pyramid loads, as compared with 2.5 per cent in the middle and top. With the 3×5 type, there was an average of 17.3 per cent deep injury in the bottom layer as compared with 2.4 per cent in the middle and top positions. In both types of loads, the average amount of shallow injury was also significantly greater in the bottom layer. These observations suggest the value of protecting the bottom with padding material.

In the 3×5 load, many floor bags were found

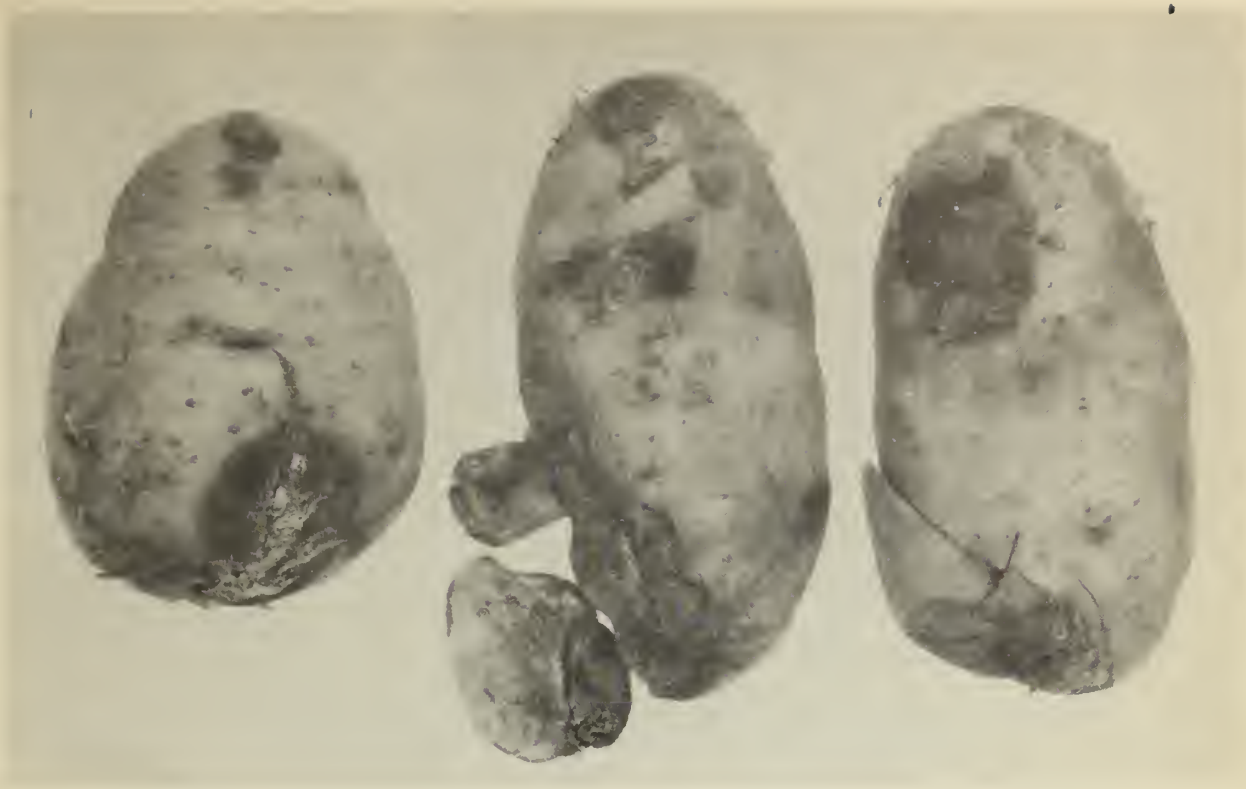

Fig. 3.--Types of transit damage classed as deep injury in this report. These were from bottom-layer bag that was not protected by floor pads.

Fig. 4.--Types of transit damage classed as shallow injury in this report.

to have rolled completely over in transit, floor-rack abrasions of bags and tubers being found on the top face of bags at the time of unloading. Comparisons between the two types of loads show a significantly greater amount of deep injury in the floor layer of the 3 × 5 load than in that of the pyramid. Shallow injuries such as browned spots and bag marks were not, however, significantly different in the floor layers of the two types of loads. As is to be expected, the two systems of loading were alike in the relatively small amount of injury occurring in the upper layers of bags.

Decay in these cars ranged from 0 to 3 per cent, averaging less than 1 per cent. In both types of loads, decay averaged slightly higher in the middle and top than it did in the floor layer, probably because transit temperature was higher in the upper part of the car. Although this difference proved to be statistically significant in the pyramid loads and not so in the 3 × 5 loads, the differences were too slight to have any practical importance. There were no significant differences in decay attributable to the type of load.

Decay was much more objectionable than is indicated by the amount shown in the table; the decayed tubers leaked slime and ooze throughout the bag and over adjacent bags, causing wet spots and covering sound potatoes with foul-smelling bacterial ooze. The receiver attempted to refuse several cars because of the slimy, smelly condition indicative of excessive decay; he accepted them only after the actual amount of decay was shown to be small.

Pretransit Injuries

The removal of all injured tubers from the bags to be used in pad tests gave an estimate of the amount of pretransit injury occurring at three packing houses. Mechanical injuries such as cuts, cracks, and deep bruises were encountered in 1.5 to 2 per cent of the potatoes sorted (table 2). About 5 to 7 per cent showed bruising. Although many of the cuts and bruises were too small to be scored against the grade, the amount found may indicate rough handling or it may indicate poorly adjusted equipment. The amount of pretransit injury in individual bags varied considerably, but averaged about the same at each of the three packing houses.

Removal of pretransit injuries at the packing house did not always improve the condition of the potatoes arriving at the market. Because of the variable amount of injury received in transit, some bags that had been free of injury before loading arrived with more injury than bags that were not re-sorted. The removal of injured potatoes from the test bags before shipping gave assurance, however, that the injury observed at unloading had occurred in transit or during the loading operation.

Effectiveness of Floor Pads in Preventing Injury

During 1944, the effectiveness of padding material was tested in 5 cars delivered to New York City and vicinity. Three of these loads were of the 3 × 5 type, and 2 were of the pyramid type. Floor pads were used under half the load in each test car. Upon arrival at the market the amount of injury, especially in the bottom bags, was much greater in the bare halves of the cars than in the padded halves (table 3).

Test bags of injury-free potatoes were shipped in the bottom and middle layers at the quarter-length position in the bare and padded halves of each car. Injury was excessive in the bare halves, regardless of the type of load used; it apparently resulted from the constant jolting received en route. Some of the cars had splintered floor racks, and in others the load shifted in transit; but apparently neither of these conditions caused any more injury than the constant jolting to which all cars were subjected.

Deep injuries observed at the market were significantly less in the padded halves of the cars than in the unprotected halves. This was true for both floor and middle positions. The shallow-type injury occurring in the floor layer was also lessened by the use of the pads. Although pads apparently reduced shallow injury in the middle layer, the difference did not prove to be significant.

The cushioning effect of the pads was also shown by the fact that fewer holes were rubbed through the bags in transit. In one test, 70 per cent of the bags in the bottom layer of the bare half of the car arrived with holes, compared with 10 per cent in the padded half.

In preliminary tests during the 1943 shipping season, floor pads were used experimentally in 14 cars. Most of the loads were diverted to army camps or to markets where the receivers failed to report the condition on arrival. Reports from receivers of 5 of the cars indicated, however, that floor damage affected 3 to 35 potatoes per bag in the bare halves of the cars, and from 0 to 7 potatoes per bag in the padded halves.

Transit Temperatures of Padded Loads

Transit temperatures in padded cars gave no indication that the pads interfered with the circulation of air through the load (table 4). Recording thermometers were placed in bags in the bottom and middle layers in the padded and bare halves of test car 11 en route to the New York area, May 17 to June 1, and in bottom-layer bags of test car 12 en route May 23 to June 3. The cars were loaded dry, iced to capacity at Bakersfield after loading, and re-iced twice in transit (rule 247) at West Laramie, Wyoming, and Chicago, Illinois. According to Weather Bureau

TABLE 1

Comparison of Arrival Condition of White Rose Potatoes Shipped in Two Types of Loads from Kern County, California, to the New York Area, 1944

Test no.	Loading station	Date unloaded	Per cent of deep injury		Per cent of shallow injury		Per cent of decay	
			Bottom layer*	Middle and top layers†	Bottom layer*	Middle and top layers†	Bottom layer*	Middle and top layers†
Pyramid type of loading								
1	Di Giorgio	May 15	5.2	0.6	5.5	6.5	0.4	0.8
2	Di Giorgio	May 17	6.2	2.4	12.6	4.5	0.1	0.9
3	Di Giorgio	May 18	9.6	2.7	14.5	7.0	1.2	1.2
4	Di Giorgio	May 20	5.5	3.0	7.3	4.1	0.5	0.4
5	Di Giorgio	May 22	5.6	0.4	7.1	2.0	0.6	0.6
6	Di Giorgio	May 27	4.3	2.0	3.1	2.7	0.0	0.3
10	Di Giorgio	May 29	6.1	3.0‡	3.1	0.0‡	0.1	0.0‡
13§¶	Di Giorgio	June 4	6.8	6.9‡	5.6	0.2‡	0.0	0.1‡
15§‖	Di Giorgio	July 7	21.6	1.9‡	26.2	3.5‡	0.0	0.2‡
3 × 5 type of loading								
7	Edison	May 27	20.8	1.9	4.3	0.2	0.0	0.0
8	Shafter	May 27	15.7	0.3	4.3	0.8	0.0	0.0
9	Patch	May 29	9.9	0.9‡	7.5	3.0‡	0.2	0.4‡
11§¶	Patch	June 1	16.6	3.3‡	13.3	1.1‡	0.0	0.0‡
12§	Patch	June 3	11.0	3.9‡	9.3	7.8‡	2.3	3.2‡
14§	Shafter	June 21	30.0	4.0‡	3.9	5.1‡	0.1	0.4‡
Average of nine pyramid loads			7.9	2.5	9.4	3.4	0.3	0.5
Average of six 3 × 5 loads			17.3	2.4	7.1	3.0	0.4	0.7

*Average of 4 to 6 bags.

†Average of 2 to 3 bags in middle layer and same number in top layer.

‡Average of 2 and 3 bags, top layer only.

§Regularly graded bags from unpadded half of car.

¶Load shifted in transit.

‖Load slightly shifted.

TABLE 2

Pretransit Injury in U.S. No. 1 White Rose Potatoes at Three Packing Sheds in Kern County, California, June 1944

Loading station	Number of sacks inspected	Average number of tubers per sack	Per cent of mechanical injury*		Per cent of slight bruises	
			Range	Average	Range	Average
Patch	8	266	0.4 — 3.6	2.0	1.9 — 8.9	5.1
Shafter	8	289	1.3 — 2.9	1.9	3.6 — 11.7	6.9
Di Giorgio	8	187	0.5 — 2.9	1.5	5.8 — 8.6	6.7

*Including cuts, cracks, and deep bruises.

TABLE 3

Arrival Condition of Padded and Nonpadded Test Bags of White Rose Potatoes; Visible Injuries Removed Before Loading

Test no.	Treatment	Condition of floor rack*	Shifting of load	Per cent of deep injury		Per cent of shallow injury		Per cent of decay	
				Bottom layer†	Middle layer‡	Bottom layer†	Middle layer‡	Bottom layer†	Middle layer‡
				Pyramid type of loading					
13	Bare	Fair	Severe	10.5§	5.9	3.9§	1.7	0.4§	0.3
13	Padded	Fair	Severe	4.6§	4.8	1.6§	2.1	0.2§	0.3
15	Bare	Poor	Slight	16.0	5.3	22.4	7.4	0.2	0.5
15	Padded	Poor	Slight	13.2	2.4	18.9	7.1	0.0	1.2¶
				3 × 5 type of loading					
11	Bare	Poor	Severe	20.9	8.0	15.3	8.0	0.0	0.0
11	Padded	Poor	Severe	9.3	3.1	13.7	2.2	0.0	0.0
12	Bare	Fair	None	10.2	4.6	9.4	2.4	0.7‖	2.7
12	Padded	Fair	None	2.6	3.5	5.7	1.4	0.1**	3.5
14	Bare	Poor	None	21.3	6.8	3.9	0.4	0.2	1.1††
14	Padded	Poor	None	16.0	1.4	2.8	0.4	0.1	0.7
Average for bare				15.8	6.1	11.0	4.0	0.3	0.9
Average for padded				9.1	3.0	8.5	2.6	0.1	1.1

*With respect to splintered and rough floor boards.

† Average of 3 bags.

‡ One bag inspected.

§ Average of 2 bags.

¶ Three other bags averaged 0.3 per cent decay.

‖ Three other bags averaged 2.3 per cent decay.

**Three other bags averaged 2.5 per cent decay.

††Three other bags averaged 0.2 per cent decay.

TABLE 4

Temperatures in Bags of Potatoes in Bare and Padded Halves of Cars During Transit*

Position in car	Treatment	Temperature, degrees Fahrenheit, at indicated days in transit															
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Test 11															
Bottom	Bare	57	43	40	39	38	37	37	37	37	37	37	37	37	37	37	37
Bottom	Padded	57	44	40	39	38	37	36	36	38	38	38	38	38	38	38	38
Middle	Bare	59	56	49	45	43	42	41	41	40	40	40	40	40	40	40	40
Middle	Padded	58	55	50	46	45	44	42	42	41	40	40	40	40	40	40	40
		Test 12															
Bottom	Bare	60	48	41	40	40	40	38	39	40	41	40	40	..	..	..	..
Bottom	Padded	60	54	45	42	41	42	41	39	40	40	40	40	..	..	..	..

*Cars initially iced at Bakersfield after loading and re-iced twice en route -- West Laramie, Wyoming, and Chicago, Illinois.

records along the Southern Pacific and Union Pacific lines, the outside temperature between Bakersfield and Chicago ranged between 40° and 66°F at night and 60° to 85° during the day. Upon arrival at Jersey City, New Jersey, the bunkers of the cars were 1/3 to 3/5 full of ice.

With this method of icing, the bottom-layer bags (originally about 60°F) cooled to about 40° in 2 to 3 days, and the middle layer to about 45°. During the latter part of the trip, bottom and middle layers were 37° and 40° respectively.

Transit temperatures were practically the same in the padded and bare halves of the cars, a fact showing that refrigeration and air circulation were not obstructed by the pads. Similar results were obtained with two test cars shipped to Chicago and New York City in May, 1943.

Commercial Considerations

In shipping tests during two crop years, the use of floor pads materially reduced bruising and other injury received in transit. Not only did the pads reduce the amount of floor damage, but apparently their cushioning effect extended up through the load and resulted in less injury, less bag marking, and fewer worn holes in the upper layers as well. Apparently there is enough jolting in transit to cause excessive bruising in nonpadded cars even when there is no evidence that the load shifted en route. Floor pads in transit kept enough potatoes from being crushed or from otherwise being made worthless by severe bruising to justify fully the cost of using them. In these tests, it was estimated that the floor pads affected savings of 1 to 4 bags of potatoes per car. The effect of this amount of injury upon the wholesale price would depend on many factors. However, the fact remains that the use of floor pads would result in the delivery of more salable potatoes to the retail market.

Inspection at packing houses before the potatoes were loaded into the cars showed less than 2 per cent mechanical injury severe enough to be scored against grade; but there were many small, shallow injuries and minor pressure bruises. The extent to which these slight pre-transit injuries caused deterioration in transit was not determined. Obviously, however, more careful handling and better adjustment of mechanical equipment used would tend to eliminate such injuries and to improve the grade at the market.

Comparisons of nonpadded 3 × 5 loads with pyramid loads indicate that less floor damage occurs in the latter. In the pyramid load, more care is required in placing the bags, and the bottom-layer bags rest flat on the floor, making a broad, solid base for the pile above. The same careful placing of the bottom bags, together with hand loading, probably would improve the 3 × 5 load over the present method of "bumping" the stacks into place. Careful handling of the bags in the car should not be overlooked because, obviously, rough treatment can cause injury regardless of the type of load used. Although floor pads were beneficial in all the tests, the greater injury occurring in unprotected 3 × 5 loads suggests a special need for cushioning material with this type of load.

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